the thermograph average. Owing to the extreme variation in the discrepancies from day to day, the use of the shorter method of computing means may introduce errors which will mask relationships between thermal influence and biological activity.

Perhaps the chief result of this study is the proof of the fact that *if approximate averages are employed, the same hour of observation should be used if the data are expected to be comparable.* The taking of readings before 8 o'clock in the evening is not to be recommended for *any* purpose, owing to the extreme differences that will be introduced in the averages.

When daily means are used in the summation of effective temperatures, or of temperature co-efficients, for the study of thermal influence in botany and zoology, thermograph averages alone should be used, since approximate means introduce rather large errors, especially during the spring months, as is shown in Table 1.

The U. S. Weather Bureau practice being to average the temperature extremes from midnight to midnight, the normals so computed are adequate for meteorological purposes. In the case of cooperative observers, who have no thermograph record by which to do this, records taken at 8 o'clock in the evening appear to be the most desirable if maximum and minimum thermometers are in use, since the errors of computation introduced are not excessive, and the hour is convenient for the observer. When the variation of the exposure of the instruments is considered, it is doubtful whether any important gain in the accuracy in the mean temperature for a month would be secured by furnishing cooperative observers with thermographs. Such are essential for biological purposes, however.

TABLE 1.—*Summation of daily mean temperatures above 39° F., Fredonia, N. Y., 1916.*

(From Apr. 11 to the end of the month indicated.)

Record.	April.		May.		June.		July.		August.	
	Summation.	Per cent discrepancy.	Summation.	Per cent discrepancy.	Summation.	Per cent discrepancy.	Summation.	Per cent discrepancy.	Summation.	Per cent discrepancy.
	°F.		°F.		°F.		°F.		°F.	
Thermograph	151.7	0	654.9	0	1,337	0	2,474	0	3,505	0
Midnight	164.5	8.4	672.5	2.7	1,374	2.7	2,523	1.9	3,561	1.6
8 p. m.	166.5	9.8	694.0	6.0	1,410	5.5	2,568	3.8	3,613	3.1
5 p. m.	183.5	20.9	744.5	13.7	1,477	10.5	2,657	7.4	3,721	6.1

PARADE-GROUND TEMPERATURES AT COLLEGE STATION, TEX.

By CHARLES F. BROOKS.

In June, 1918, at College Station, Tex., some observations were made of parade-ground temperatures under different conditions of cloudiness, and were also compared with temperatures in the grass and air. The instrument was a physical thermometer upon which the boiling point was about 101.5° C., and the freezing point at 0.2° C. The temperatures mentioned below are uncorrected for instrumental error. The influence on the dust temperature of the passage of the shadow of a cumulus cloud is shown in the following table:

About sunrise the next morning it was found that the temperature in the dust was about 27.8° C., in the air about 1 meter above the ground, 25.9° C., and in the grass 24.7° C. In the afternoon, with the thermometer placed under 2 or 3 mm. of dust, a temperature of 61.3 C°. (142° F.) was obtained; in the grass 48.6° C. (120° F.); in the air about 38° C. (101° F.). In this case it is noted that the breeze seemed to make little difference with the temperatures of the dust. The maximum temperature was obtained when the thermometer was placed in a dust hole slope normal to the sun's rays. A temperature of 61.7° C., or about 143° F., was obtained.

TABLE 1.—*June 18, 1918.*

Time (p.m.).	Thermometer.	Remarks.
	°C.	
3:08	59.5	Exposed in gray dust at depth of ½ cm. for 5 minutes. Sun had been shining for some time.
3:09	53.1	Beginning of cumulus shadow.
3:17	53.1	In cloud shadow. Sky cover 0.6 St.Cu., 0.2 Ci.St.
3:20	51.9	Still in shadow.
3:21	51.6	Do.
3:22	51.3	Do.
3:22:30	51.1	Sun reappearing.
3:23:30	52.4	Strong sunlight.
3:24:30	53.6	Do.
3:25:30	54.7	Do.
3:27:30	45.3	Under green grass, about 1 cm. from top of grass, and so placed that direct sunlight did not strike bulb. In poor air circulation. Strong sunlight.
3:28	43.8	Same exposure.
3:29	42.8	Do.
3:29:30	42.2	Light clouds.
3:30	41.7	Do.
3:31	40.8	Very light clouds.
3:32	40.5	Beginning of thick cloud. Gusty east wind.
3:45	38.5	Air temperature on roof of three-story building in thermometer shelter.

HIGH RELATIVE TEMPERATURES OF PAVEMENT SURFACES.

By G. S. EATON.

[Abstracted from the Engineering News-Record, Mar. 27, 1919, p. 633.]

Maximum temperatures, relatively high with respect to adjacent locations, were found by engineers of the Universal Portland Cement Co., on asphalt, brick, and concrete surfaces. From 11 a. m. to 6:30 p. m. the average readings for the three types of surfaces in the order named were 118°, 113°, and 108°. This is of special interest with respect to the effect of these high temperatures on rubber tires, horses' hoofs, and shoe leather. It is known that a large part of the tire trouble experienced by motorists is due to expansion of the air due to heat. High pavement temperatures would doubtless play a large part in aggravating this condition.

"During the middle of the day the effect of the pavements in heating the air above them was noticeable, as thermometers 1 foot and 4 feet above the roadways read from 3½ to 4½° higher than over a lawn in the sun. Temperatures above the pavements were found to be much the same, however, regardless of the type of surface. Over the asphalt, the readings averaged 1° higher than above the concrete and one-half degree higher than above the brick. After 7:30 p. m. the temperatures above the surfaces were practically the same as those of the surrounding air. The presence of large lawns and shade trees probably hastened the cooling and somewhat different results might be expected in the closely built-up sections of a city. Temperatures in the shade, 30 feet away, were not influenced by the pavements."

These tests were made in Riverside, Ill., far enough inland to escape the lake breeze and all the pavements were in the same vicinity. Weather conditions were ideal, as the sky was clear, and the air temperatures recorded at Chicago were the highest of the summer.

"For each pavement, readings were taken at the surface, 1 foot and 4 feet above, and 30 feet to one side of the roadway in the shade of a lawn. An additional set of readings was taken 4 feet over grass in the sun. Thirteen standard 25 cm. Fahrenheit thermometers were used, each protected from direct sunlight by a white paper or pasteboard cover. Readings were taken every half hour from 8 a. m. to 10 p. m."

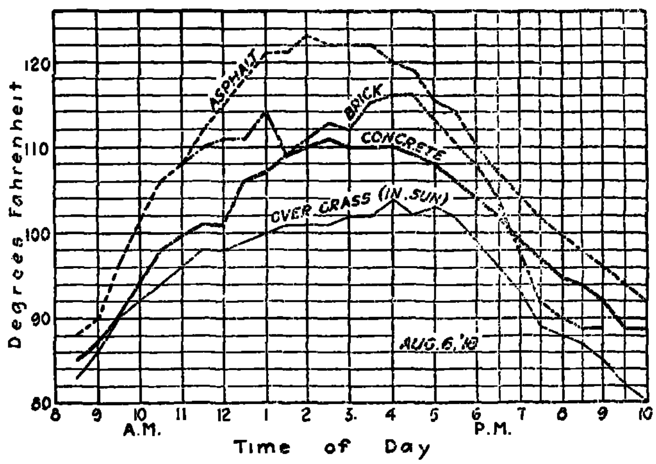

FIG. 1.—Surface temperatures for various types of surfacing.

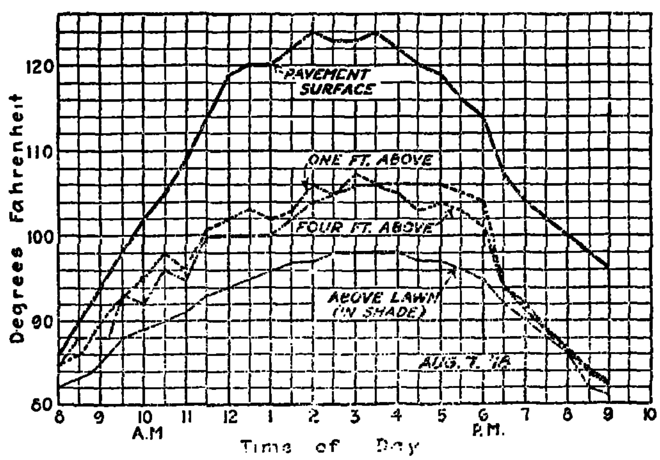

FIG. 2.—Variation between asphalt surfaces and various adjacent locations.

Figures 1 and 2 show sets of readings plotted between temperatures as ordinates and time of day as abcissae. "Figure 1 shows the difference between the various pavement surface temperatures and also the readings over a lawn in the sun. The drop in the brick temperature curve at 1:30 p. m. was due to the moving of the observation station on account of the encroachment of shade. No point could be found on the brick surface that was in the sun for the entire day. The rapid drop in the same curve between 6 and 8 p. m. was probably due to the proximity of the Des Plaines River, as air temperatures taken near showed a similar drop. Figure 2 shows the relation, for an asphalt pavement, between temperatures at the surface, 1 foot above, 4 feet above, and in the shade 30 feet to one side of the roadway."—*C. L. M.*

COMPARISON OF ROAD-SUBGRADE AND AIR TEMPERATURES.

By C. C. WILEY.

[Abstracted from Engineering News-Record, July 17, 1919, pp. 128-129.]

"Investigations were started at the University of Illinois in the belief that some of the phenomena of cracking and heaving of brick and concrete roads can be explained by a study of the range and rate of change in temperatures within the pavement and in the underlying soil. The observations will extend over a considerable period of time to obtain data concerning some of these factors." Preliminary records show that changes in temperature are transferred very slowly from the air to the subsoil, and that the subgrade extremes lag considerably behind those of the air.

"The fact that the changes of temperature at the bottom of the slab are considerably slower and much less in magnitude than those of the air may be worth considering in connection with protecting a new pavement from freezing. Also it may be noted that the change from maximum to minimum temperatures in the slab takes place over a considerable length of time, during which the slab and subgrade have an opportunity to adjust themselves to the changed conditions."—*C. L. M.*

PENETRATION OF PERIODIC TEMPERATURE WAVES INTO THE SOIL.

By K. AICHI.

[Reprinted from Science Abstracts, Sect., A, Mar. 31, 1919, § 240.]

The paper deals in a theoretical manner with the conduction of heat through a substance such as the soil. In working out the annual temperature wave at depths of 1 m., 2 m., and so on from that at the surface it is customary to assume the conductivity and specific heat constant throughout each layer. This is far from being the case, and it is shown that the assumption invalidates the results of such calculations. The ratio of the conductivity to the specific heat can be obtained (1) from the change of amplitude of the temperature wave with depth, and (2) from the retardation of phase, and in certain practical examples to which the formulæ are applied in the customary manner it is found that the results from (1) and (2) are in very poor agreement. In the paper certain cases where the conductivity varies with depth in a specified manner are treated mathematically.—*J. S. Di.*

NEW METHOD OF REDUCTION OF OBSERVATIONS OF UNDERGROUND TEMPERATURE.

By K. AICHI.

[Abstract reprinted from Science Abstracts, Apr. 30, 1919, p. 151. Art. in Phys.-Math. Soc., Japan, Proc. 1 (Ser. 3) pp. 2-7. Jan., 1919.]

A further discussion concerning the passage of the annual temperature wave downward through the soil, where the conductivity K and specific heat C vary with depth, see Abs. 240, 1919. If temperature observations were available at all depths, K and C could be calculated uniquely as functions of the depth, but actually, where observations at certain specified depths only are taken, a definite solution of the problem is not possible. Various methods of calculating the "equivalent diffusivity" of the layer between two points of observation are discussed and numerical examples are worked out.—*J. S. Di.*